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SOME TRACE ELEMENT CONTENTS OF THE COMMON BASEMENT ROCKS OF THE SAFAGA REGION, EASTERN DESERT OF EGYPT

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ABSTRACT

Fourteen samples from the common igneous types forming the basement in the Safaga area were analysed by emission spectrography and neutron activation techniques and their contents n the following 22 trace elements were determined: B, Ba, Be, Co, Cr, Cs, Cu, Hf, La, Ni, Pb, Rb, Sc, Sm, Sr, Ta, Th, U, V, Y, Yb and Zr. The results obtained are discussed and compared with those of the corresponding world's averages.

All the Safaga basement rocks are apparently geochemically strongly impoverished in boron, ather impoverished in copper and lead but somewhat enriched in nickel, cobalt, and yttrium. The ranitic rocks are also rather impoverished in vanadium but rather richer in barium, strontium, hafnium and beryllium than the corresponding world's averages.

INTRODUCTION

Volcanics, subvolcanics and plutonic igneous rocks almost entirely form the asement rocks in the Safaga area. In a previous communication, GINDY *et al.* [1971] ad discussed the geochemical relations between the common basement rocks of the Safaga area. These relations were based on field observations and on chemical anayses for the major elements.

Away from the contact aureoles of younger intrusive rocks, the volcanics are lightly metamorphosed but other basement rocks are on the whole not metamorphosd or foliated. The granodiorite of Safaga is of batholitic dimensions, extending eyond the limits of the area studied and is variable in appearance, homogeneity and omposition.

In certain parts, it encloses several xenoliths, like metagabbros and hornblendeneisses. The batholith is truncated to the east by the Red Sea rift fault. The stratified olcanics occur in a deformed state in the sunken caldera of Gebel Nuqara, down nside the granodiorite and were thus protected from removal by erosion.

A "riebeckite-granite" intrusion occupied the fissures around the collapsed aldera and thus formed a ring-dyke but minor intrusions of the same granite were ent into all possible spaces and fractures of the country rocks. The adamellites also ccur as major intrusions into the granodiorite but the remaining "red-granite", uartz-porphyry and granit-porphyry intrusions occur as common late very minor rregular dyke intrusions dissecting all pre-existing rocks.

The different rock types of the analysed samples are given in Appendix 1 and heir locations are shown in *Fig. 1*, which also serves as a simplified geologic sketchap for the area studied.

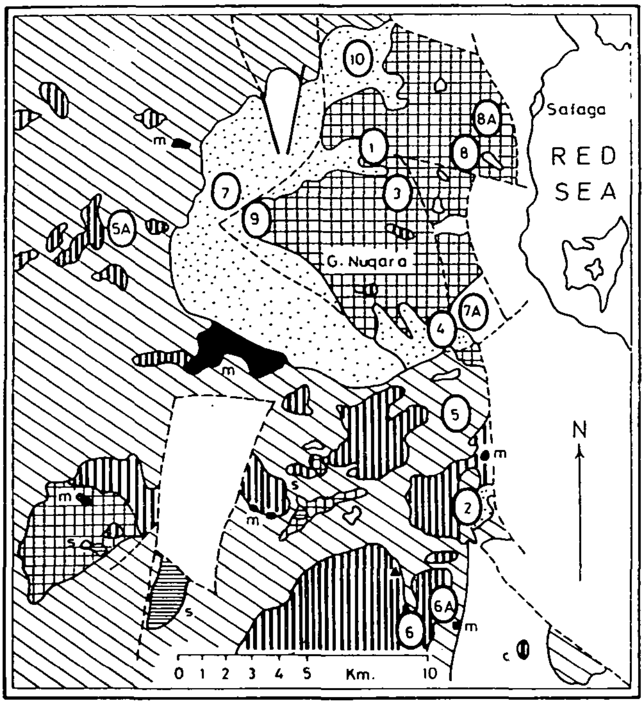


Fig. 1

PETROCHEMISTRY OF THE SAFAGA BASEMENT ROCKS

The technique used in the major element analysis was described earlier by GINDY *et al.* [1971]. The results of major element analyses for the 14 samples are given in Table 1, and the corresponding C. I. P. W. norms, NIGGLI values are given in Tables 2 and 3, respectively.

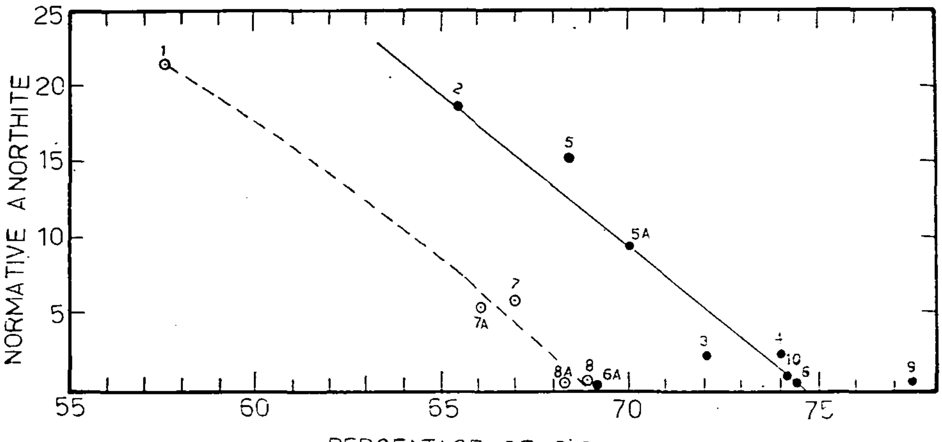


Fig. 2

TABLE 1

Complete chemical analyses (weight per cent) for the Safaga basement rocks

Oxides	1*	2*	3*	4*	5*	5—A	6*	6—A	7*	7—A	8*	8—A	9*	10*
SiO_2	57.53	65.43	72.05	73.85	68.69	70.10	74.37	68.80	67.08	66.06	69.23	68.25	77.51	74.17
Al_2O_3	18.16	15.68	11.83	12.69	14.39	15.59	12.06	15.23	15.41	14.74	13.67	14.21	9.83	13.08
Fe_2O_3	0.52	1.72	1.52	0.93	0.32	2.41	0.64	1.92	0.42	2.11	2.12	1.86	1.29	0.49
FeO	2.62	1.51	1.68	0.88	2.77	1.13	1.02	0.83	2.58	1.86	1.21	0.86	1.31	0.49
MnO	0.10	0.22	0.15	0.04	0.12	0.14	0.11	0.11	0.14	0.11	0.18	0.15	0.12	0.08
MgO	3.98	3.16	1.05	0.40	2.86	0.75	1.10	1.06	1.30	1.35	0.54	0.53	0.40	0.40
CaO	6.74	4.23	1.20	0.70	3.10	1.90	0.90	0.53	1.44	1.39	0.66	0.56	0.70	0.80
Na_2O	4.20	4.69	4.32	3.78	3.38	6.10	4.09	5.81	4.18	3.51	4.02	5.55	2.68	4.18
K_2O	2.45	1.05	3.64	5.19	2.80	1.51	5.04	5.83	5.38	6.01	7.09	7.47	5.40	5.42
TiO_2	1.34	0.92	1.02	0.36	0.62	0.50	0.32	0.25	1.04	1.13	0.70	0.23	0.42	0.32
P_2O_5	0.08	0.06	0.07	0.18	0.06	0.08	0.21	0.15	0.10	0.17	0.21	0.30	0.08	0.11
H_2O^+	0.16	1.49	1.49	1.10	0.56	0.61	0.45	0.38	0.53	1.10	0.41	0.39	0.40	0.42
H_2O^-	0.06	0.05	0.05	0.02	0.04	0.05	0.05	0.01	0.05	0.07	0.09	0.08	0.04	0.01
Total	99.92	100.21	100.07	100.12	99.57	100.87	100.36	100.90	99.65	99.61	100.13	100.44	100.18	99.97

* Values quoted from GINDY *et al.* [1971].

TABLE 2

C. I. P. W. Norms of the Safaga basement rocks

Norm	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
Qz	4.57	21.72	29.61	30.30	25.14	23.90	29.22	11.29	16.38	17.47	18.66	14.00	40.74	27.59
Or	14.49	6.12	24.52	30.58	16.68	8.89	30.02	34.47	31.69	35.52	41.70	44.10	31.69	32.06
Ab	33.50	39.82	36.51	31.96	28.82	51.50	33.01	45.74	35.11	29.65	31.44	31.10	20.44	35.33
An	23.42	18.63	2.11	2.22	15.29	9.00	—	—	6.39	5.97	—	—	—	0.88
C	—	—	—	—	0.10	0.62	—	—	0.41	0.35	—	—	—	—
Ac	—	—	—	—	—	—	1.85	2.95	—	—	2.31	5.30	1.85	—
Di	7.56	1.94	2.95	0.45	—	—	2.32	3.94	—	—	1.33	0.68	2.32	2.12
Hy	8.68	7.13	2.21	1.06	11.30	1.87	1.29	—	6.20	4.70	1.16	2.18	1.29	0.22
Mt	0.75	2.55	2.20	1.39	0.46	2.18	0.93	1.29	0.70	3.00	1.86	—	0.93	0.71
Hm	—	—	—	—	—	0.25	—	—	—	—	—	—	—	—
Il	2.53	1.82	1.94	0.76	1.22	0.94	0.76	0.47	1.98	2.14	1.37	0.42	0.76	0.61
Ap	0.19	—	0.16	0.34	0.13	1.60	0.34	0.35	0.34	0.35	0.67	0.70	0.34	0.26
Na metasilicate	—	—	—	—	—	—	—	—	—	—	—	2.24	—	—

TABLE 3

NIGGLI *values for the Safaga basement rocks*

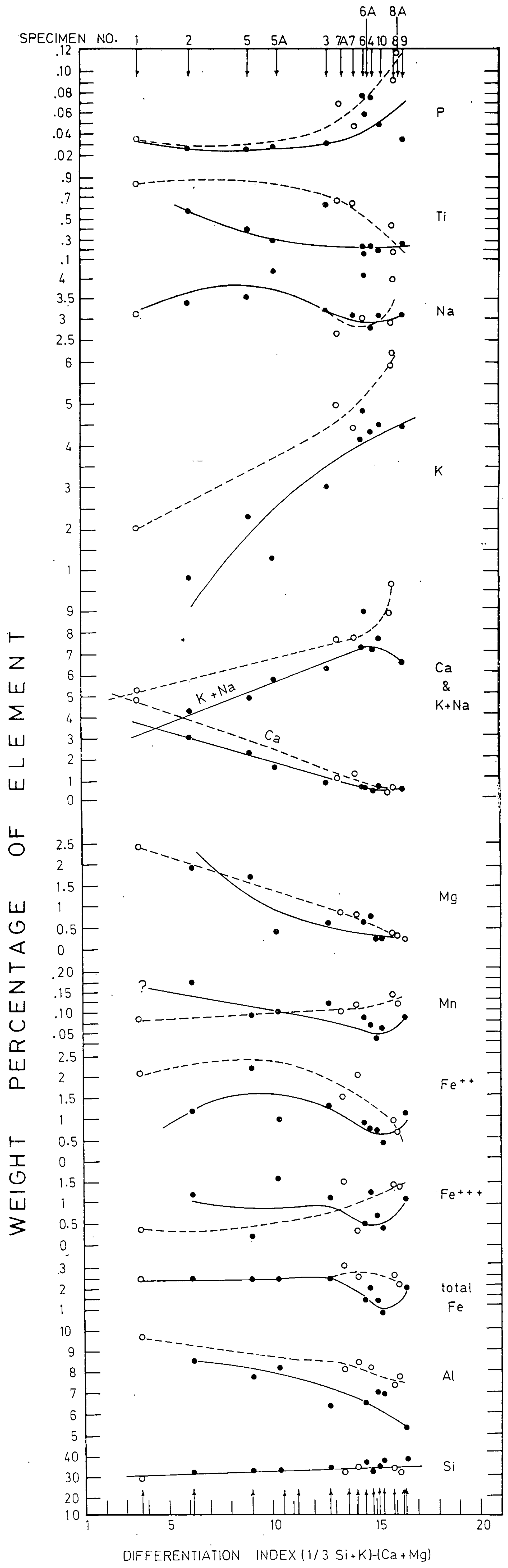
NIGGLI values	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
si	179.3	250.5	378.9	327.4	285.5	318.2	407.9	303.4	295.8	300.0	335.4	316.3	506.7	424.7
al	33.3	34.8	36.6	43.0	35.3	41.6	38.5	39.5	39.9	39.4	38.9	38.7	37.6	44.0
fm	26.7	28.3	22.4	12.2	29.8	18.0	16.8	16.8	20.4	23.8	17.3	14.0	18.0	8.2
c	22.4	17.2	6.6	4.5	13.8	9.2	5.3	2.5	6.9	6.8	5.3	2.8	5.2	4.8
alk	17.6	19.7	34.4	40.3	21.3	31.1	39.5	41.2	32.8	32.8	40.3	47.0	39.2	43.0
ti	3.2	2.7	4.1	1.7	2.0	1.7	1.3	0.82	3.4	3.8	2.5	0.77	32.0	1.4
p	0.18	0.09	0.31	0.34	0.10	0.13	0.65	0.27	0.26	0.29	0.57	0.58	0.39	0.34
k	0.35	0.14	0.36	0.47	0.35	0.13	0.45	0.39	0.46	0.53	0.53	0.47	0.36	0.46
mg	0.70	0.63	0.38	0.28	0.62	0.28	0.55	0.41	0.43	0.38	0.23	0.26	0.23	0.42

TABLE 4

Trace element contents of the Safaga basement rocks
(values in ppm)

ELEMENT	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
B	4	1	1	1	11	1	3	1	3	1	1	1	1	1
Ba	750	70	826	250	410	143	950	1255	1102	1460	780	500	57	37
Be	2	1	2	7	2	5	11	4	4	7	4	4	11	13
Co	26	8	22	10	12	6	11	10	4	15	11	9	13	3
Cr	63	3	21	15	3	2	9	17	2	2	1	1	8	6
Cs	2.4	1.4	2.7	2	2.4	2.6	2.3	1.4	1.6	1.1	1.4	1.8	2.6	2.1
Cu	20	12	6	5	16	8	7	2	12	15	9	13	3	11
Hf	5.1	4.2	5.9	4	4.5	6.3	5.2	18	12.3	13.4	17.6	19.2	6.1	5.7
La	N. D.	27	27	58	5	2	58	86	27	27	56	48	96	56
Ni	98	10	48	9	38	17	20	18	7	8	7	6	14	8
Pb	6	9	14	23	5	10	11	16	11	10	11	11	14	22
Rb	10	17	47	95	29	70	85	88	53	76	66	120	124	100
Sc	7.2	18.3	9.2	2.4	1.1	2.5	2.8	1.8	9	6.2	5.7	3.5	2	1.3
Sm	7.5	6.6	5.9	6.4	8.4	7.3	5.4	9.8	11.1	12.2	12.6	10.2	8	3
Sr	520	290	423	273	410	330	285	430	305	320	240	225	130.2	40
Ta	0.3	0.4	0.9	1.9	0.6	0.8	1.8	2.4	2.6	2.7	2.9	2.8	1.9	1.4
Th	0.6	0.8	5	11	6.9	6	12.1	3.8	4	9.1	6.8	7.5	10	12.5
U	0.2	0.4	1.7	4.4	3	2.8	3.5	1.2	1.6	2.7	3.1	3.5	4.2	5.3
V	115	15	63	32	129	31	5	19	6	15	12	2	11	2
Y	N. D.	55	15	24	24	22	24	22	12	24	31	32	73	12
Yb	2.7	3.3	3	3.1	2.6	2.6	2.4	2.6	2.2	3	3	2.6	3.4	2.2
Zr	480	640	440	670	390	420	395	395	450	470	560	700	190	68

N. D. = not detected.



SPECIMEN NO.
WEIGHT PERCENTAGE OF ELEMENT
DIFFERENTIATION INDEX (1/3 Si+K)-(Ca+Mg)
P
Ti
Na
K
Ca & K+Na
K+Na
Ca
Mg
Mn
Fe++
Fe+++
total Fe
Al
Si

Fig. 3

In the different diagrams of *Figs. 2* to *6*, plotting of the newly analysed "riebeckite-granite" and "red-granit" samples nos. 7A and 8A, each fall very near to those of the corresponding samples analysed earlier (nos. 7 and 8).

The new granodiorite sample (no. 5A) is, however, much more sodic, slightly higher in total iron but poorer in potash, magnesia and lime than the first granodiorite sample no. 5. On the other hand, plots of the hybrid adamellite sample no. 6A interestingly often follows the slightly alkaline suite *(Figs. 2, 4, 5* and *6)* suggesting some drawing out of alkalies, especially soda from the enclosed darker granodioritic xenoliths and their addition to the enclosing adamellite.

Field evidence for the transitions occurring between the granodiorite and adamellite are present though they are very few. Except for the adamellite, the bulk size of the rest of the normal calcalkaline intrusives is very small. The adamellite in addition might have also been generated by small weaker renewed activation and remelting of the deeper part of the granodiorite batholith itself whether it had already solidified or was solidifying.

Alkalic (potassic) fluxing activities by volatiles and hyperfusible constituents during magmatic intrusion of the normal adamellite magma under sub-volcanic,

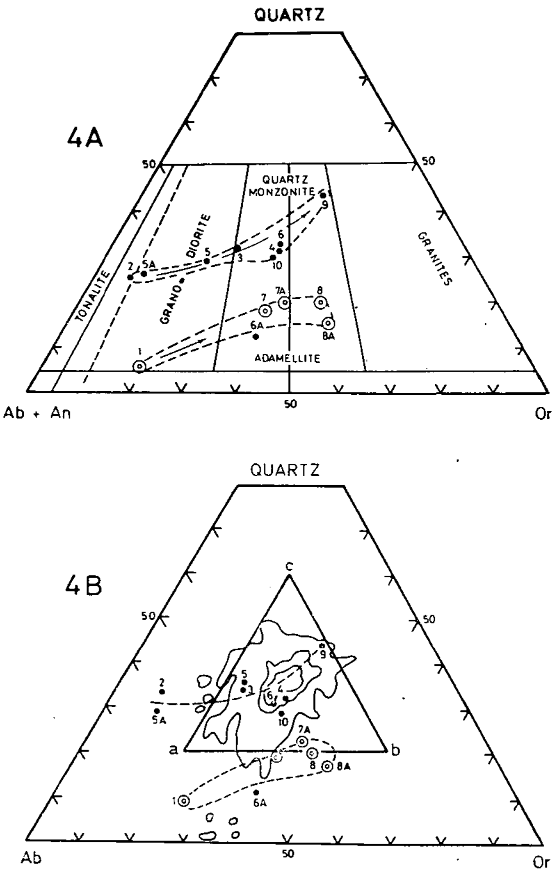


Fig. 4

superheated condition are considered to account for the slight alkalinity shown by the "riebeckite-granite" of the ring-intrusion. The later "red granite" intrusions might similarly have evolved through strong potassic hyperfusible and volatile activities on late minor granitic pockets of residual magmas.

From the variation diagrams of *Fig. 3*, it can be noticed that almost no significant changes occur in the curves for sodium and total iron except perhaps at differentiation indices above 14. Irregularities in the ferrous and ferric curves must have in part, been affected by the original state of oxidation of iron and the extent of its

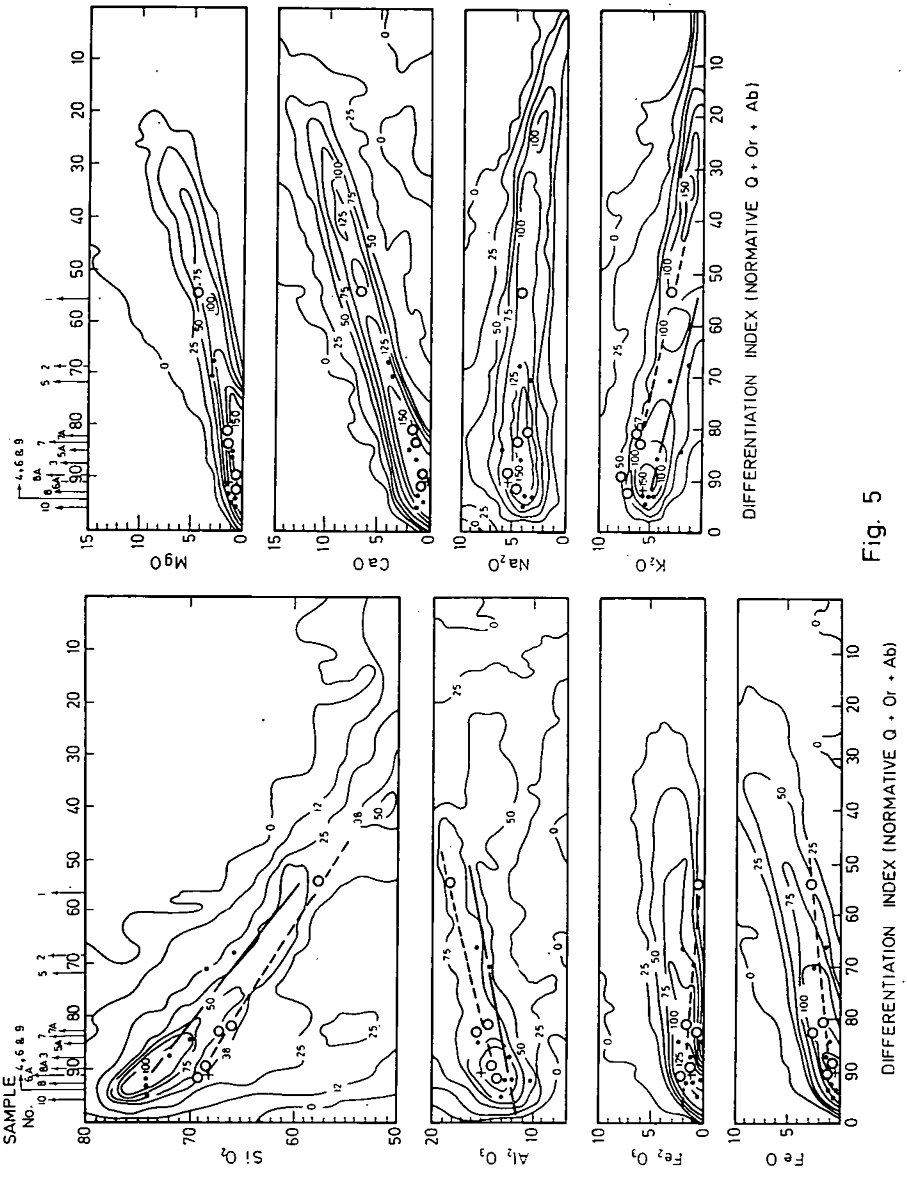


Fig. 5

oxidation during volcanic extrusion and/or subsequent metamorphism or hydrothermal acitivities subsequent to intrusion.

Conventially, phosphorous decreases with increasing acidity except in certain pegmatitic residua, but in the curves for both suites of Safaga, phosphorous increases with increasing acidity and is slightly higher for alkaline than calc-alkaline suite. This suggests some concentration of phosphorous in the "residual magma" at Safaga, but late gaseous transfers could also be invoked for this increase.

It is seen from *Fig. 4B*, that apart from the dacite sample no. 2, all calc-alkaline members fall within the contour of maximum frequency of 1269 igneous rocks in Washington's tables containing 80%. or more of normative (Ab+Or+Q). The five alkaline samples of trachandesite (no. 1), "riebeckite-granite" (no. 7, 7A) and "red granite" (no. 8, 8A) all fall outside these contours although the normative (Ab+Or++Q) of the last four alkaline samples exceed 80.

Direct treatment and comparison of data of the analysed "volcanics" (samples nos. 1, 2, 3 and 4) with those of the "plutonites" may be debatable because of the possible interfering effects of volcanicity on varying the actual igneous primary

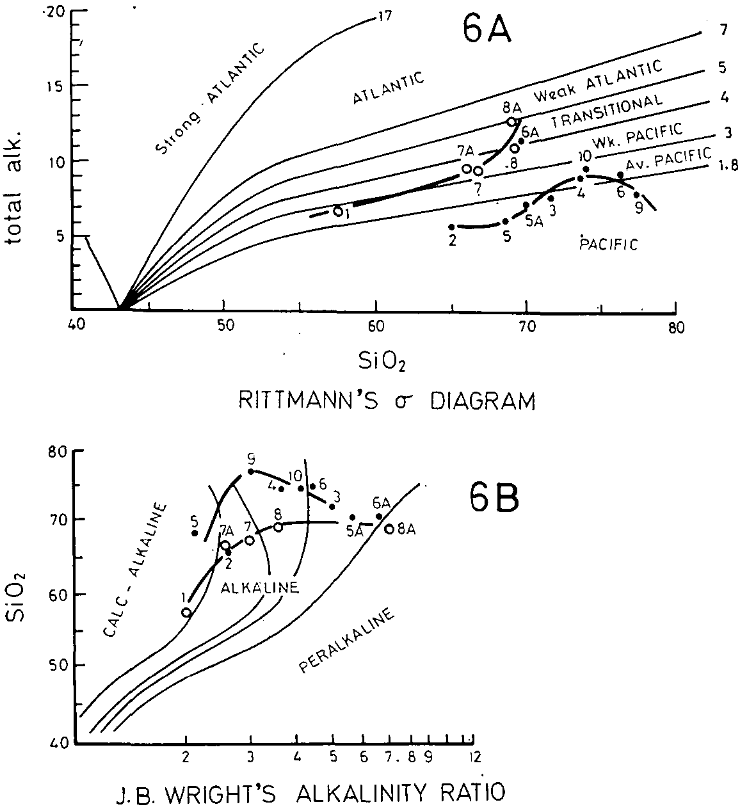


Fig. 6

composition of the lava, e.g. by gaseous transfer and other effects of vapours and sublimates and oxidising conditions. This collective treatment and correlation of the "volcanics" and "non volcanics" of Safaga may be here justified by the belief that a very close genetic relationship existed between these volcanics and some of the granitoids.

GEOCHEMISTRY

Trace element analysis:

Two methods were applied to determine 22 trace elements for all the 14 rock samples.

1 — Spectrochemical method for determining B, Ba, Be, Co, Cr, Cu, La, Ni, Pb, Sr, V, Y, Yb and Zr.

2 — Neutron activation technique to determine Cs, Hf, Rb, Sc, Sm, Ta, Th and U.

For the first method, the spectrograph used is a Q—24 Carl Zeiss medium quartz spectrograph supplied with an intermittent D. C. source. The generating power is a Carl Zeiss ABR3 with a maximum voltage of 28 kV at 220 V. Operating conditions for arching, technique of work as described elsewhere, ANWAR *et al.* [1971].

For the second method ,the neutron activation scheme used was based on different irradiation (A. C.) carried out at a thermal neutron flux of 1.5×10^{13} n/cm^2 sec. The detector used for this study was a coaxial Ge(Li) detector with a resolution of 2.5 keV (FWHM), detail of the method, see ANDERS, [1969], and BRUNFELT *et al.* [1969, 1974].

The trace element data are presented in Table 4. It is clear from the analysis, that sample no. 10 of the latest and most acid one (with high D. I.) in Safaga, possesses the lowest content of Ba, Sr, V, Co, Y, Yb, La and Sm. It is also impoverished in Ni and Cr. On the other hand, sample no. 1 of the trachyandesite is the most basic and it possesses the highest content of Sr, Cr, Ni and Co and is also enriched in V, Cu and Cs.

Trace element contents of the adamellite, "riebeckite-granite" and "red granite" are roughly closer to each other but are quite different from those of the Safaga granodiorites. The "red granite" sample no. 8A shows higher values of Hf, Ta, Rb, Th and U, and lower values of Ba, Sr, Co and Ni than the "riebeckite-granite" sample no. 7A. The adamellite sample no. 6A has higher values of Ba, Cr, Hf and Ta and lower data for Cu, Th and U than the granodiorite sample no. 5A.

In all the diagrams, plots of the normal calc-alkaline suite are represented by solid black circles, plots of the alkali-calcic suite (samples nos. 1, 7, 7A, 8 and 8A) are shown by centered open circles, while plots of the hybrid adamellite sample no. 6A are shown by crosses.

The behaviour of the 22 determined trace elements may conveniently be studied under the following six groups:

1 — *Ba, Sr, Pb, Rb and Cs*

Both Ba and Sr decrease with strong differentiation. Furthermore, two trends may be observed for Ba and Sr in the calc-alkaline and alkali-calcic suites. In *Figs. 7A* and *7B*, both elements are relatively higher in the alkali-calcic suite than in the normal suite.

Figs. 7C and *7D* show an increase of Pb with increase of D. I. and with high K contents, respectively. The calc-alkaline suite is relatively richer in Pb than the alkali-calcic suite as Pb is readily captured and admitted by K.

There is functional antipathetic relation between Ba and Rb, *Fig. 8A*, where two possible trends could be suggested. The "riebeckite-granite", "red granite" and the

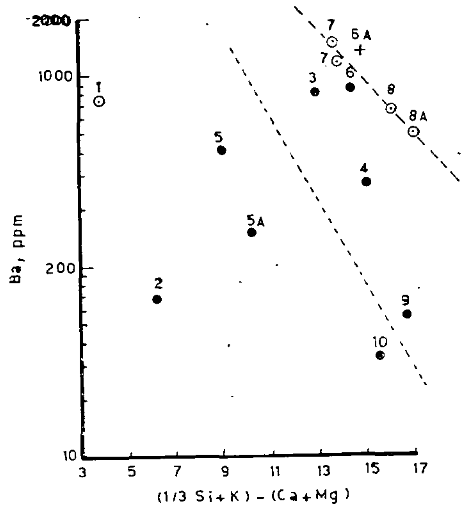


Fig. 7A

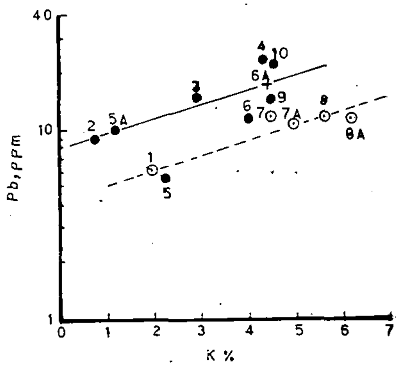


Fig. 7C

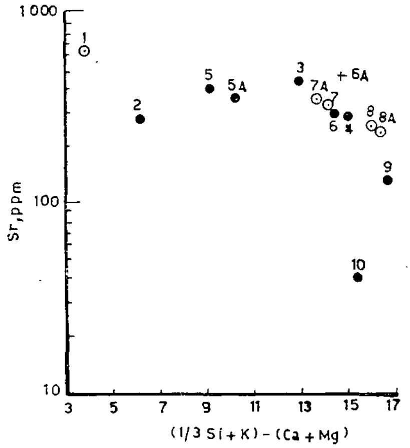


Fig. 7B

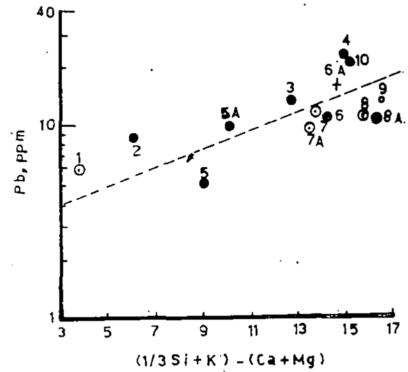


Fig. 7D

adamellite samples show general enrichment in Ba beside a depletion in Rb. The trachyandesite sample no. 1 shows strong depletion in Rb and an enrichment of Ba, in contrast to the quartz-porphyry sample no. 9 and the late rhyolite dyke sample no. 10 which have higher Rb values than Ba. This probably suggest that the tonalite might have evolved later by partial remelting of the earlier granodiorite formed by anatexis or by direct magmatic differentiation from the newly formed granodioritic magma.

2 — *V, Cr, Co and Ni*

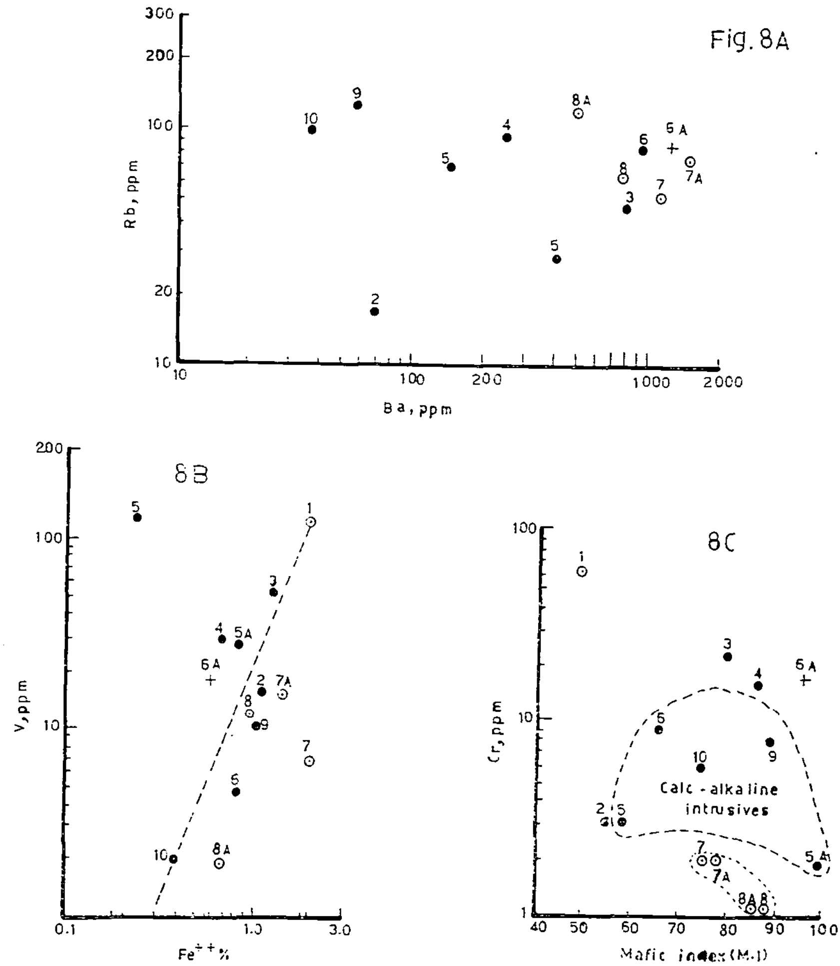
These elements are known to follow Mg and Fe in their geochemical behaviour. All decrease with increase of D. I. *Fig. 8B* indicates an increase of V with Fe^{++}, the granodiorite sample no. 5 possesses a high value of V and occupies a separate position. *Fig. 8D* shows two fields for the alkali-calcic suite of Safaga ("riebeckite and red granites") and the calc-alkaline intrusions.

3 — *B, Be and Cu*

Boron contents of the Safaga basement rocks are notably very low compared with those of the corresponding world's average. Actually not a single crystal of tourmaline was observed in all the studied collection of thin sections from the Safaga basement rocks.

Be increases with the increase of differentiation index of the Safaga basement rocks. This agrees eith BEUS's data [1956], for igneous rocks in general as quoted by TAYLOR [1965].

Coherence of Be concentration to silicon content of rocks has been pointed out by SHAWE and BERNOLD [1964]. It will be noticed from *Fig. 9A* that sample nos. 9, 10 and 6 possess high silica as well as high Be contents. The alkali-calcic suite of Safaga seems to occupy a distinct field in this figure.



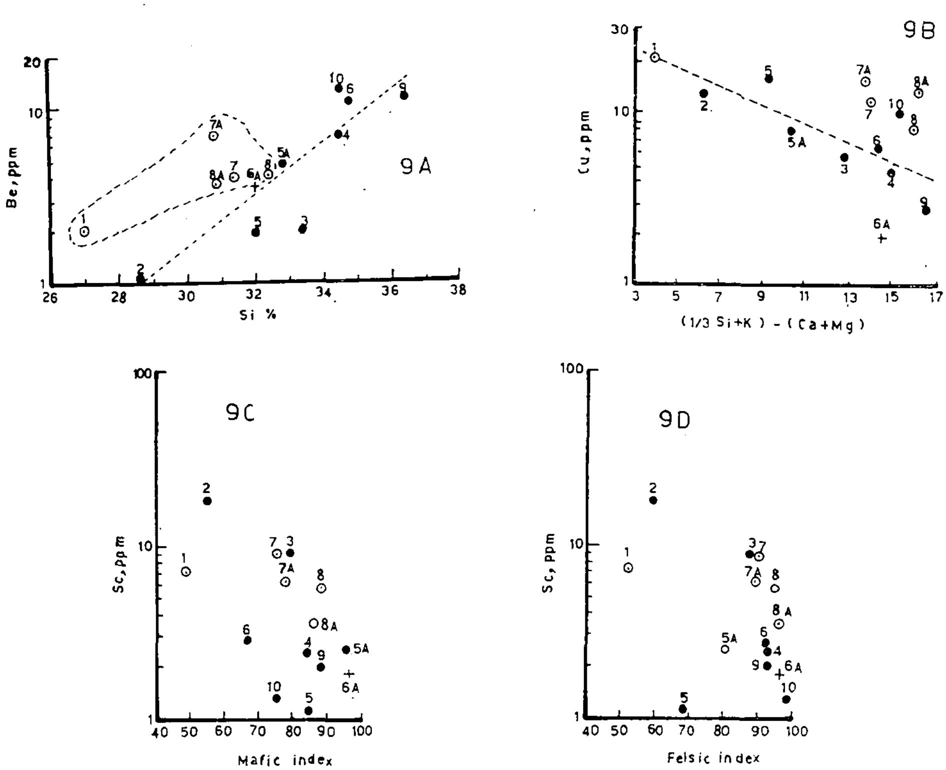


Fig. 9

As can be seen from *Fig. 9B*, Cu decreases with increase of differentiation index in Safaga. In general, Cu is relatively high in the "riebeckite and red granites", meta-dacite and rhyolite dyke of Safaga although the highest contents are those of the trachyandesite and one of the granodiorite samples.

4 — *Y, Yb, La, Sm and Sc*

Yttrium and the lanthanides (including Yb) can substitute for Ca^{++} of some accessory minerals in granite like apatite, titanite, epidote and fluorite [Rankama and Sahama, 1952; Goldschmidt, 1954 and Mason, 1964]. Y, Yb and La elements do not show a clear relation with the differentiation index in the Safaga basement rocks.

In general, the alkali-calcic suite of Safaga tends to have higher Sm values than the calc-alkalic suite. Sc decreases with increase of the differentiation index in Safaga rocks. Sc contents appear to be higher in members of the alkaline-calcic suite than the corresponding members of the calc-alkaline suite. The complex behaviour of Sc may be shown by its decrease with increase of both mafic and felsic indices, *Figs. 9C* and *9D*.

5 — *Zr, Hf and Ta*

Zirconium and hafnium form a pronouncedly coherent pair of elements [Rankama and Sahama, 1952]. The abundance of Zr in igneous rocks has been considered by CHAO and FLEISCHER [1960]. This paper shows very clearly the increase of Zr with fractionation.

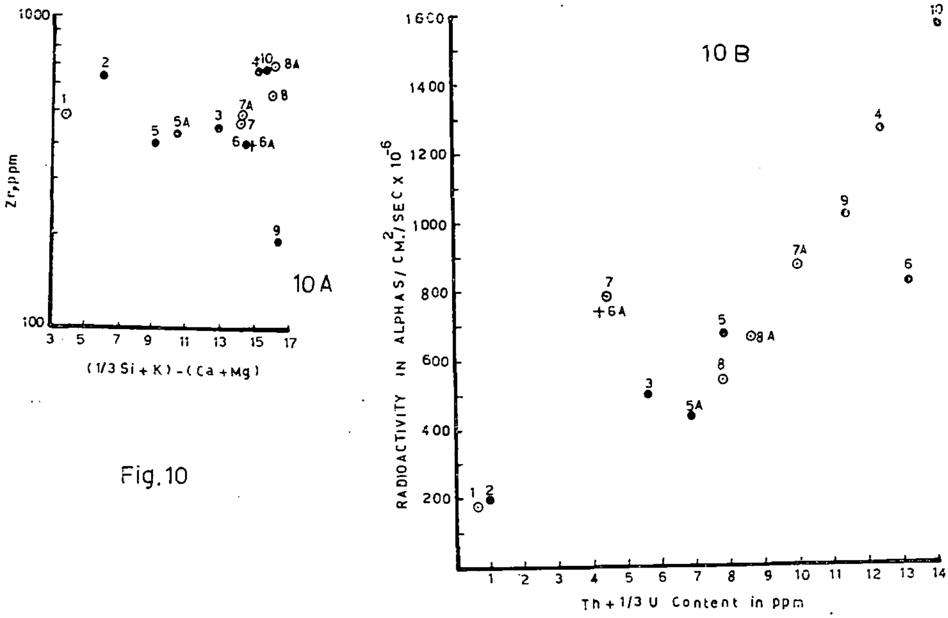


Fig.10

For the Safaga basement rocks, Zr appears to increase with increase of the differentiation index, (*Fig. 10A*) which is the normal trend in igneous rocks [TAYLOR, 1965]. No clear distinction between the two Safaga suites could be made on the basis of their Zr contents.

The alkali-calc suite of Safaga basement rocks show higher Hf values (av. 156. ppm), and lower Zr/Hf ratio (av. 35) than the calc-alkali suite which has an average value of 5.2 ppm Hf and 112.7 for Zr/Hf ratio.

Ta may substitute for Ti^{4+} and Zr^{4+}. In the Safaga basement rocks, the alkali-calc suite shows an average value of 2.8 ppm Ta, while the calc-alkaline suite has an average of 1 ppm Ta.

6 — *U and Th*

Quadrivalent uranium and thorium are geochemically coherent due to similarities in oxidation state and ionic radius. The relation between U and Th from one hand and differentiation from the other is the subject of considerable research. However, there is general agreement that both U and Th increase with differentiation, but the controversial Th/U ratio can either increase or remain constant with differentiation [RAGLAND *et al.*, 1967]. In the Safaga basement rocks, the ratio of Th/U is more or less constant, it varies from 2 to 3.5.

Fig. 10B indicates that the summation of Th $+\frac{1}{3}$ U in the Safaga basement rocks increases with alpha radioactivity and the most radioactive rocks are the acid ones (ignimbrite, rhyolite dyke and quartz-porphyry of samples nos. 4, 10 and 9.

WHITFIELD *et al.* [1959], found that there is greater petrogenetic control of thorium than of uranium content, and this may be explained on the basis of oxidation and repeated loss of uranium from magmas during the later stages of their differentiation.

SUMMARY AND CONCLUSIONS

From the preceding study on the behaviour and distribution of the trace elements of Safaga basement rocks, the following conclusions may be summed up.
1 — Cu, Sc, Sr, Cr, Co, Ni and Ba contents of the basement rocks of Safaga decrease with increase of their differentiation index, while Pb, Be, Rb, U, Th and Zr increase.
2 — The trachyandesite sample no. 1 is enriched in Ca and Mg and also in V, Cr, Co and Ni contents. This supports the suggestion previously expressed in GINDY *et al.* [1971], that a weak alkalinity of this rock is caused by original mixing of a basaltic magma and acidic anatectic magma or by mixing of their differentiates. In the "riebeckite- and red granites" the weak alkalinity is believed to be caused by potassic fluxing under subvolcanic superheated conditions. It is worth to mention that the "riebeckite and red granites" are enriched in Ba, Rb, Zr, Hf and Ta.
3 — The hybrid character of the granitoid, sample no. 6A, at the transitional contact between a xenolith granodiorite and adamellite in Safaga is reflected in the major and trace element contents of that rock.

Compositional plotting of the different elements in that rock often oscillate between those of the two petrogenetic suites of Safaga whenever a distinction between the two suites becomes apparent in the diagram.
4 — Geochemically the Safaga basement rocks are distinctly impoverished in boron. If the data for the granodiorite, trachyandesite and dacite samples of Safaga are averaged, their average contents in Ba, Sr, V, Yb, Sc, Rb, Zr, and Be generally agree with the corresponding values for the world's average granodiorite.

The large decrease in Cr contents of the two Safaga granodiorites could be due to the suggested origin by differential melting of the Safaga granodiorite from pre-existing rocks at deeper levels of the crust. However, the nine Safaga samples are impoverished in V, and Cr and enriched in Ba, Rb, Sr, Y, La, Sm, Th, Hf and Zr.

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APPENDIX 1

Rock types and locations of the analysed samples

1— Trachyandesite (field-number of 653) from the volcanic succession of Gebel Nuqara.
2— Dacite (field-number of 300) least affected parts of a large mechanically stopped block inside the adamellite intrusion, Wadi Safaga area.
3— Rhyolite (field-number of 410) from the pile of volcanic flows of Gebel Nuqara.
4— Rhyolitic ignimbrite (field-number of 254) from Gebel Nuqara volcanics, northern bank of Wadi Nuqara.
5— Granodiorite (field-number of 565) from Wadi Um Ifein.
6— Adamellite (field-number of 317) Um Huetat area, from a big homogeneous intrusion.
7— "Riebeckite-granite" (field-number of 90) Wadi Um Taghir, on the present Quena-Safaga motor-road.

8— "Red-granite" (field-number of 385) intruded into the volcanic succession north of the triangulation point of Gebel Nuqara.
9— Quartz-porphyry dyke (field-number of 568) intruded into the volcanics of the western parts of Gebel Nuqara.
10— Late rhyolite dyke (field-number of 191) cutting into riebeckite-granite, and also truncating porphyry intrusions in the riebeckite-granite.
5A— Granodiorite (field-number of 124) from the medium grained dark granodiorite in Wadi Um Taghir.
6A— Adamellite (field-number of 310) from Wadi Um Huetat, and the sample was selected from the adamellitic part in between the granodioritic inclusions.
7A— "Riebeckite-granite" (field-number of 252) from small discrete intrusion in the ignimbrite flows at the mouth of Wadi Nuqara.
8A— "Red granite" (field-number of 88) from small discrete red intrusion in the dark meta-volcanics facing Safaga town.

APPENDIX 2

Comparison between the average contents of some trace elements in the Safaga basement rocks with those of the corresponding world's averages. (values in ppm)

Element	SF. 1	T. W. 1	SF. 2	T. W. 2	SF. 3	T. W. 3
B	4	5	4.3	9	1.5	10
Ba	750	330	343.3	420	710	480
Be	2	1	2.5	2	7.2	3
Co	26	48	13	7	9.6	1
Cr	63	170	17.8	22	6.8	4.1
Cs	2.4	1.1	2.2	2	1.8	4
Cu	20	87	14	30	8.6	10
Hf	5.1	2	5	2.3	11.3	3.9
La	N. D.	10	11.3	45	56.9	55
Ni	98	130	40.8	15	10.8	4.5
Pb	6	6	7.5	15	14.3	19
Rb	10	30	31.5	110	89.7	170
Sc	7.2	30	7.3	14	3.8	7
Sm	7.5	5.3	7.5	8.8	8.8	10
Sr	520	465	387.5	440	249.8	110
Ta	0.32	1.1	0.5	3.6	2.3	4.2
Th	0.6	4	3.6	8.5	8.5	17
U	0.2	1	1.6	3.0	3.3	3
V	115	250	72.5	88	11.6	44
Y	N. D.	21	33.7	35	28.2	40
Yb	2.7	2.1	2.8	3.5	2.7	4
Zr	480	140	482.5	140	501.1	175

SF. 1 Trace element contents of the trachyandesite sample no. 1.
T. W. 1.: Average contents in basaltic rocks of the World's (after TUREKIAN and WEDEPOHL, 1961).
SF. 2.: Average contents of the Safaga samples nos. 1, 2, 5 and 5-A.
T. W. 2.: Average contents for the World's high-calcium granitic rocks (granodiorites), after TUREKIAN and WEDEPOHL, 1961.
SF. 3.: Average contents of the nine Safaga samples nos. 4, 6, 6-A, 7,7-A, 8, 8-A, 9 and 10.
T. W. 3.: Average contents for the World's low-calcium granitic rocks (granites), after TUREKIAN and WEDEPOHL, 1961.

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